BULLETIN

OF THE INSTITUTE OF METALS

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INSTITUTE NEWS

1953 May Lecture

SIR CHRISTOPHER HINTON, M.A., M.I.C.E., M.I.Mech.E., Deputy Controller of Atomic Energy (Production), Ministry of Supply, has accepted the Council's invitation to deliver the 1953 May Lecture. His subject will be "The Present and Future Metallurgical Requirements of the Chemical Engineer".

The lecture will be delivered (in connection with the Annual General Meeting) at the Royal Institution, Albemarle Street, London, W.1, on Monday, 23 March 1953 at 6 p.m.

Appeal to Industry for Regular Financial Support of the Institute's Work

The following additional contributions—other than renewals of donations—have been received in response to the Council's appeal to industry for regular financial support of the Institute's work:

	£	s.	d.
Tata Iron and Steel Co., Ltd., The	21	0	0
Foundry Services, Ltd.	10	10	0

A full list of contributions received up to 31 December 1951 was printed on pp. 346–347 of the February, 1952, issue of the *Journal*; lists of donations subsequently received have been published on pp. 39 (Feb.), 51 (March), 65 (April), 81 (June), and 92 (July) of this volume of the *Bulletin*.

The Secretary will be glad to send, to any firm which has not yet subscribed, copies of the Council's letter of appeal and printed form of covenant.

Representation of the Institution of Metallurgists

Dr. MAURICE COOK and Dr. E. G. WEST have been nominated to succeed Mr. E. W. COLBECK and Mr. L. ROTHERHAM as representatives of the Institution of Metallurgists at meetings of the Council of the Institute, for purposes of liaison.

Abstractors Required

The Editor would be glad to hear of members who would be prepared to undertake abstracting work for *Metallurgical Abstracts*, especially of members with a knowledge of languages and with access to a technical library. Specialists in analysis, foundrywork, and welding are particularly required.

Election of Members

The following 15 Ordinary Members and 2 Student Members were elected on 4 September 1952:

As Ordinary Members

BLACKMORE, Kenneth Gordon, A.I.M., Technical Assistant, Library and Information Section, Aluminium Laboratories, Ltd., Banbury, Oxon.

BOVENSIEPEN, *Dr.* Otto Rudolf, Managing Partner, Kupfer und Messingwerke Becker, G.m.b.H., Langenberg, Rhineland, Germany.

COLNER, William H., B.S., M.S., Research Metallurgist, Armour Research Foundation, 35 West 33rd Street, Chicago 16, Ill., U.S.A.

DIAMOND, Randolphe William, B.A.Sc., LL.D., D.Sc., Executive Vice-President, Western Region, Consolidated Mining and Smelting Company of Canada, Ltd., Trail, B.C., Canada.

FONSECA, Olga de Toledo, Librarian, Biblioteca do Instituto de Pesquisas Tecnológicas, Caixa Postal 7141, São Paulo, Brazil.

FUJIWARA, Tadayoshi, B.S., M.S., S.D., Consultant, International Nickel Company, Inc., c/o Imperial Chemical Industries (Japan), Ltd., 435 Tokyo Hotel Building, Tokyo, Japan.

HORN, Heinz, Technical Director, Felten und Guilleaume Carlswerke Aktiengesellschaft, Köln-Mülheim, Germany.

JOHNSTON, Thomas Wilson, Blast Furnace Technical Assistant, Ford Motor Co., Ltd., Dagenham, Essex.

LAYTON, Frank, Area Sales Manager, Northern Aluminium Co., Ltd., 27 Park Row, Leeds 1.

LEWIS, Francis George, B.Sc., Research Metallurgist, Aeronautical Research Laboratory, G.P.O. Box 4331, Melbourne, Australia.

PLATT, Geoffrey Frank, Technical Director, Platt Metals, Ltd., Great Cambridge Road, Enfield, Middx.

RICHARDS, Arthur, B.Sc., Metallurgist, Royal Ordnance Factory, Woolwich, London, S.E.18.

ROBINS, Dudley A., B.Sc., A.I.M., Research Laboratories, The General Electric Co., Ltd., Wembley, Middx.

SCOTT, J. Walter, M.S., Western Electric Co., Inc., Hawthorne Works, Chicago 23, Ill., U.S.A.

SWANK, Raynard Coe, A.B., B.S., Ph.D., Director, Stanford University Libraries, Stanford, Calif., U.S.A.

As Student Members

FLINN, Ian, B.Sc., Research Physicist, The British Aluminium Company, Ltd., Research Laboratories, Chalfont Park, Gerrards Cross, Bucks.

GRIFFITHS, David, B.Sc., Student of Metallurgy; (mail): 46 Marble Hall Road, Llanelly, South Wales.

International Tables for X-Ray Crystallography

Volume I (Symmetry Groups) of the International Tables for X-Ray Crystallography, published for the International Union of Crystallography, is now ready. The text and tables (in English) have been planned to be of the maximum practical usefulness in the determination of crystal structures and in allied problems, but their value for teaching purposes has also been kept in mind. The price is £5 5*s*. (five guineas) inclusive of postage and packing; cloth binding, 558 + x pp., 237 figures, with dictionary in English, French, German, Russian, and Spanish. Members of the Institute of Metals may obtain one copy, for their personal use only, at the subscription price of £3, post free, by using a special order form available, with the prospectus, from the Kynoch Press, Witton, Birmingham 6, England.

Volumes II and III, which are in preparation and which will be sold separately, will cover Mathematical, Physical, and Chemical Tables used in X-ray crystallography.

"Metallurgical Abstracts" Volumes Wanted

The Institute will pay £1 each for bound volumes, in good condition, of *Metallurgical Abstracts*, 1940 (vol. 7), 1941 (vol. 8), 1942 (vol. 9), and 1943 (vol. 10).

The Institute will also pay 7*s*. 6*d*. each for copies, in good condition, of the following monthly parts of the *Journal and Metallurgical Abstracts*:

1940, Jan., Mar., Apr.	1942, July.
1941, July.	1943, May, July, Aug., Sept., Oct.

Copies offered for sale should be addressed to the Secretary.

PERSONAL NOTES

Mr. E. A. Allen has joined the staff of the Bahrein Petroleum Co., Ltd. His address will be Mail Box No. 738, Awali, Bahrein, Persian Gulf.

Dr. N. P. Allen has been elected a Vice-President of the Institution of Metallurgists.

Mr. J. Arnott has been elected a Member of Council of the Institution of Metallurgists.

Mr. G. L. Bailey has been appointed a Member of Council of the British Iron and Steel Research Association.

Professor C. S. Barrett, who has been working in the Metallurgy Department at Birmingham University, has now returned to the Institute for the Study of Metals, University of Chicago, Chicago 37, Ill., U.S.A.

Mr. W. D. Biggs has been nominated by Murex Welding Processes, Ltd., to undertake a programme of research in the Department of Metallurgy, Birmingham University. He will return to his firm when the programme is completed.

Mr. N. I. Bond-Williams has been elected a Member of Council of the British Non-Ferrous Metals Federation.

Mr. R. P. Bradshaw has been awarded the Ph.D. degree of Cambridge University and is now a Metallurgist in the Central Research Laboratories of the Vacuum Oil Co., Ltd.

Dr. A. de Sales Brasunas has taken up a post in the Metallurgy Division of the Department of Chemical Engineering, University of Tennessee, Knoxville, Tenn., U.S.A.

Mr. W. F. Brazener has been elected a Vice-President of the British Non-Ferrous Metals Federation.

Mr. D. F. Bridges is now a metallurgist with D. Napier and Son, Ltd., Luton Airport, Beds.

Mr. G. W. Brown has been appointed Honorary Secretary of the Bristol and West of England Branch, Institute of British Foundrymen.

Mr. H. H. Burton has been elected a Vice-President of the British Iron and Steel Research Association.

Mr. R. D. Carter has recently been awarded the Ph.D. degree of Durham University and is now with the Plessey Co., Ltd., Ilford, Essex.

Mr. J. Chadwick has left England for Northern Rhodesia.

Mr. A. R. Cook has left the Almag Engineering Co., Ltd., Liverpool, to take a position as a metallurgist at Aluminium Laboratories, Ltd., Banbury.

Mr. H. J. Davies has completed the course for the Diploma in Graduate Studies in Industrial Metallurgy at Birmingham University, and has returned to his post with Richard Thomas and Baldwins, Ltd., Briton Ferry, Glam.

Mr. P. Flatley has completed his studies at the Royal School of Mines, being awarded the B.Sc.(Eng.) and A.R.S.M., with second-class honours, and is now with Associated Lead Manufacturers, Ltd., Chester.

Mr. H. C. Gibbins has been elected a Vice-President of the British Non-Ferrous Metals Federation.

Mr. R. B. Gibbon has been awarded the B.Sc. degree of Durham University.

Dr. E. Gregory has been elected a Vice-President of the Institution of Metallurgists.

The Hon. John Grimston, M.P., Director and General Manager, Enfield Rolling Mills, Ltd., has been elected a Member of Council of the Production Engineering Research Association of Great Britain.

Professor A. Guinier is to spend several months at the University of Illinois.

Professor A. G. Guy has been appointed Associate Professor of Metallurgical Engineering, Purdue University, West Lafayette, Ind., U.S.A.

Mr. P. V. Hunter has resigned his position as Deputy Chairman of British Insulated Callender's Cables, Ltd., but will continue as a non-executive director of the Company and will remain on the boards of several subsidiary companies.

Mr. H. E. Jackson has been appointed President of the British Non-Ferrous Metals Federation. Mr. Jackson is Chairman of the Metals Division, Imperial Chemical Industries, Ltd.

Dr. J. W. Jenkin has been appointed a Member of Council of the British Iron and Steel Research Association.

Mr. James T. Kemp has ended his period of service in the Defence Materials Procurement Agency of the U.S. Government and has taken a post in the Aluminum Department of the Anaconda Copper Mining Company.

Mr. J. A. N. Lawrie is now a Plant Metallurgist with the Australian Aluminium Co. Pty., Ltd., Granville, N.S.W.

Mr. D. M. Lewis has left the Research and Development Division of the British Steel Founders' Association and taken a post as Senior Investigator at Aluminium Laboratories, Ltd., Banbury.

Mr. A. H. Lines has been awarded the B.A. degree of Cambridge University.

Sir Andrew McCance has been appointed a member of the East Kilbride Development Corporation.

Miss M. MacKenzie has been awarded the B.Sc. degree of Durham University, and is now working as a research student at King's College, Newcastle-upon-Tyne.

Mr. N. A. McKinnon is now at the Department of Metallurgy, Birmingham University.

Dr. H. L. Maxwell, Supervisor of Mechanical Engineering Consultants, E. I. du Pont de Nemours and Co., Inc., has been elected President of the American Society for Testing Materials for the year 1952–53.

Mr. N. L. Mochel, Manager of Metallurgical Engineering, Westinghouse Electric Corp., Lester Branch, has been elected a Vice-President of the American Society for Testing Materials for a term of two years.

Mr. A. Morton has been awarded the degree of B.Met. at Sheffield University.

Mr. G. R. Morton has been appointed Senior Lecturer in Metallurgy at the County Technical College, Wednesbury.

Dr. L. Northcott has been elected a Member of Council of the Institution of Metallurgists.

Professor H. O'Neill has been elected President of the Institution of Metallurgists. He has also been appointed a Member of Council of the British Iron and Steel Research Association.

Mr. H. M. Otte has left Birmingham and is now in the Department of Metallurgical Engineering, Case Institute of Technology, Cleveland 6, O., U.S.A.

Professor Albert Portevin has been awarded the Lavoisier Medal by the Société d'Encouragement pour l'Industrie Nationale in recognition of his contributions to science, in particular his work on stainless steels.

Dr. W. I. Pumphrey has been admitted as a Liveryman of the Worshipful Company of Blacksmiths.

Mr. Donald Rae has been elected a Member of Council of the British Non-Ferrous Metals Federation.

Professor G. V. Raynor has returned to Birmingham University after working for some months at the Institute for the Study of Metals, Chicago.

Mr. L. D. Roblin has taken a post with the Ministry of Supply, A.I.D., Technical Branch.

Mr. D. A. Ryder has been transferred from the laboratories of Joseph Lucas, Ltd., at Birmingham to the firm's Gas Turbine Equipment works at Broad Green, Liverpool, where he will hold the position of Senior Metallurgist.

Dr. George Sachs has been appointed Director of Metallurgical Research at the Institute of Industrial Research, Syracuse University, East Syracuse, N.Y., U.S.A.

Mr. H. C. Sharma is undergoing training at the Ruhrstahl A.G., Heinrichshütte, Hattingen, West Germany.

Dr. C. Sykes has been elected President of the Institute of Physics.

Mr. W. B. Taylor has been transferred from Witton to the new works at Kirkby, near Liverpool, of Imperial Chemical Industries, Ltd., Metals Division.

Mr. G. Thomas has been awarded the B.Sc. degree of the University of Wales with First-Class Honours in Metallurgy.

Mr. C. J. Thwaites has left the British Non-Ferrous Metals Research Association and is now employed in the Tinplate Section of the Tin Research Institute, Greenford, Middlesex.

Mr. H. Vickers has been awarded the degree of B.Sc. in Applied Science at Durham University.

Dr. E. G. West has been elected a Member of Council of the Institution of Metallurgists.

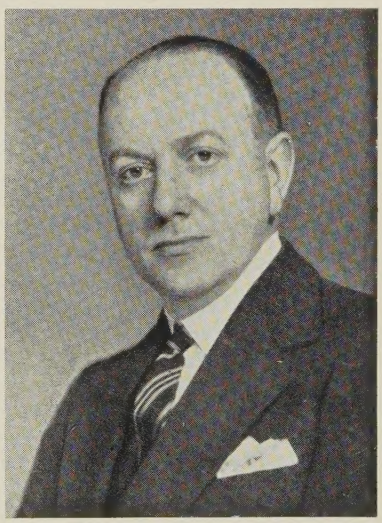
Mr. C. G. Williams has resigned his position with Norton Motors, Ltd., Birmingham, and taken up an appointment with Garringtons, Ltd., Bromsgrove, as Heat-Treatment Superintendent.

OBITUARY

Sir William Griffiths

The death of Sir William Griffiths, a Past President of the Institute, occurred on 30 July 1952, at Redhill, Surrey, after a short illness.

William Thomas Griffiths was born on 19 April 1895, the son of the Rev. Caradoc and Elizabeth Griffiths, and spent his early life in Wales, of which country he always remained a staunch adherent. After receiving his technical training at University College, Cardiff, he graduated in 1915 with the degree of B.Sc. in pure science, but his further academic career was interrupted at that stage by the war, and he served with the Royal Engineers, in France, until 1918. On demobilization he returned immediately to the University, to specialize in metallurgy, which was destined to become his life's work. In due course he was awarded the M.Sc. (Wales) in that subject.



For a brief period Griffiths held an appointment in the Metallurgy Department of his College, before, in 1921, taking up a post in the Physical Metallurgy Section of the Metallurgical Branch, Research Department, Woolwich, under Dr. Harold Moore. During his five years in that Department Griffiths made substantial contributions, in collaboration with Dr. J. L. Haughton, to the designing of improved apparatus for the study of transformations in steels, and to the perfecting

of other equipment for investigation of physical phenomena in metallic materials. From this point in his career may be dated his keen interest in the physical metallurgy of steel, and his studies at that period can be regarded as the initial stage of the research for which he was awarded the D.Sc. (Wales) in 1938.

In 1926 Griffiths joined the staff of the newly formed Research and Development Department of The Mond Nickel Co., Ltd., and from that date until 1945 he directed the gradually expanding interests of that Department. He brought to this work a practical outlook noteworthy in one whose background had, until that time, been essentially academic, and it was a characteristic feature of his direction that, while fully alive to the purely scientific interest of a subject, and while advocating a fundamental approach as being the most effective method of attacking metallurgical problems, he was always conscious that any research project should, if possible, have a practical aim. During the years spent as Manager of the Research and Development Department, in spite of rapidly increasing commitments on technical committees and other outside bodies, Griffiths maintained close touch with all sections of both laboratory and development work, and his wide metallurgical knowledge, combined with a highly critical attitude and a gift for meticulous attention to detail, contributed much to the attainment of a high standard in the work for which his Department was responsible.

Throughout the years 1939–45 Griffiths worked in close collaboration with the Ministries and other Government Departments. He served on a number of specialist committees, and, at the request of H.M. Government, undertook various missions to Canada and the U.S.A., in connection with metals supplies, alloy steels, aircraft materials, and kindred subjects. Among the developments of the war years with which he was closely associated may be mentioned high-temperature alloys for gas-turbine construction and improved aero-engine sparking-plug alloys.

In 1945, following the death of Mr. D. Owen Evans, Griffiths was appointed Chairman and Managing Director of The Mond Nickel Co., Ltd., and Vice-President of The International Nickel Company of Canada, Ltd. He was knighted in 1946. In December 1950 he left The Mond Nickel Company, but continued to take an active interest in the metallurgical world, both academic and industrial, serving on the Advisory Council of the Department of Scientific and Industrial Research, and on other bodies associated with the interests of pure and applied science.

From the earliest days of his metallurgical life Griffiths took part in the activities of the Institute of Metals, and was a warm advocate of membership of appropriate scientific and technical societies as a means of giving and receiving maximum benefit in one's profession. He served as the energetic honorary secretary of a Local Section of the Institute, as representative of the Local Sections on the Council of the Institute, as an Ordinary Member of Council, as a member of various committees, as a Vice-President and, in 1944–46, as President of the Institute. In the difficult years at the end of the war, and in the immediate post-war period, his breadth of outlook and unfailing realization of the place which the Institute should occupy internationally in the metallurgical world earned the gratitude of those who worked with him. Griffiths was also a Fellow of the Royal Institute of Chemistry, a Fellow of the Institute of Physics, a Founder Fellow of the Institution of Metallurgists, and a member of the Iron and Steel Institute and of numerous American metallurgical and chemical societies.

A subject in which Griffiths took a particularly keen and practical interest was that of scientific and technical education, especially on the university and post-graduate levels. During his Presidency of the Institute of Metals, the National Certificate in Metallurgy was established, and he was closely associated with the foundation of the Mond Nickel Fellowships. He served on a number of committees concerned with the improvement of scientific, technical, and technological training and was Chairman of the Metallurgists' Sub-Committee appointed by the Technical Personnel Committee of the Ministry of Labour and National Service to enquire into "Present and Future Demand for Persons with Professional Qualifications in Metallurgy", which issued its report in 1951. Griffiths was warmly in favour of the fuller recognition of the status of the graduate technologist, *vis-à-vis* that of the research scientist, and advocated that revised schemes for education which might be implemented in the future should provide for higher degrees open to the graduate who had subsequently specialized on a high level in the technical industries, thus permitting him to rank *pari passu* with the pure scientist, who alone is at present in the running for such distinction.

At the time of his death Sir William was the Institute's representative on the Parliamentary and Scientific Committee and also on the interim board of governors of the new international journal *Acta Metallurgica*.

L. B. Pfeil.

LETTERS TO THE EDITOR

Intercrystalline Cracking of Brass

In my previous letter (*Bulletin*, 1952, **1**, (12), 104), I drew attention to the possibility of the movement of vacant lattice sites under stress, and their accumulation at grain boundaries, being a cause of intercrystalline cracking. At that time I envisaged the vacant sites forming a uniform layer at the boundary and thus leading to a breakdown of cohesion. Tensile stress across the boundaries would then cause separation and ultimate cracking.

We have been working on the intercrystalline cracking of copper and brass in inert atmospheres, and have noticed a phenomenon which, it is suggested, is associated with the movement and aggregation of vacant lattice sites.

70 : 30 brass breaks by intercrystalline cracking at 400° C. with about 10% elongation (rate of extension 0·5%/min.). Microsections of α-brass strained in this way were prepared by removing the surface with various grades of carborundum paper, polishing with diamond dust and magnesia, and giving a light electrolytic etch to reveal the structure. The following observations were made:

(*a*) The grain boundaries contained cavities of various sizes.

(*b*) In general, there were no such cavities at twin boundaries or within the grains.

(*c*) There appeared to be some relationship between the occurrence of cavities and orientation change across a given boundary. For example, when twinned zones reached a boundary the cavities would appear to be associated with the main orientation but not with the twin orientation, or vice versa.

(*d*) Series of cavities appeared preferentially in these boundaries transverse to the tensile stress axis.

(*e*) In many cases the cavities were sufficiently close to form a continuous crack. That the cracks had formed from

the previously existing holes was evident from their serrated outline and from the observation of all stages between isolated cavities and actual cracks.

(*f*) The grain-size increased during stretching, from 0·1 to 0·25 mm. dia., and the cavities were always in the boundaries of the final grains, suggesting that the cavities "anchored" the grain boundaries.

(*g*) The surfaces of the grains in the fracture were mottled, as though the original cavities which first formed were still present. (This appearance is in contrast with the smooth facets of the intercrystalline crack caused by mercury.)

In order to observe this phenomenon in its earlier stages, three specimens of the brass (previously annealed at 600° C.) were strained 5% at 400° C. in 2, 20, and 200 min., respectively.

FIG. 1.—70 : 30 Brass Stretched 5·2% at 400° C. in 200 min. × 100.

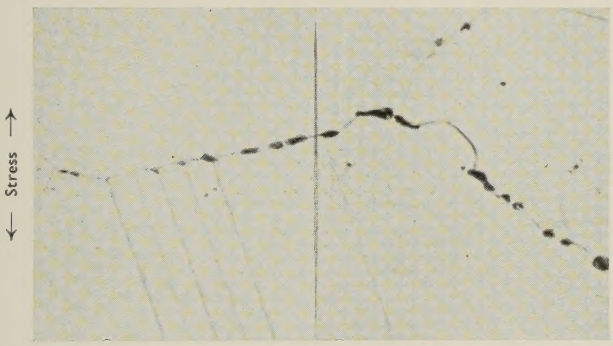


FIG. 2.—As Fig. 1. × 500.

All showed the above-mentioned phenomenon. A typical transverse grain boundary of the interior is shown in Figs. 1 and 2 at magnifications of 100 and 500 respectively.

It is now suggested, as a result of these microscopic observations, that the vacant sites which may be present originally or *created during deformation* accumulate in the appropriate boundaries not as a uniform layer but in preferred localities to form cavities. The smallest we have seen so far appears to be $0{\cdot}5 \times 10^{-4}$ cm. in dia., though the actual size may be smaller because of diffraction effects.

The formation of minute cavities in brass under strain at elevated temperature has been illustrated by Whitaker [1] and by Hérenguel and Scheidecker.[2] These latter authors place a different interpretation on the relationship between cavities and cracks. They suggest that the former are produced from the latter ("les fissures . . . fragmentent en éléments discontinus.") They continue: "Le méchanisme de cette fissuration n'apparait pas encore clairement, mais nous pensons qu'il s'apparente au phénomène de dézincification."

My tentative view of the mechanism of formation of an intercrystalline crack under the circumstances described (continuous strain at elevated temperature) is as follows:

(i) During deformation vacant lattice sites form in the crystals.

(ii) As atomic movements occur—whether thermal or translational—these vacant sites are transferred to certain crystal boundaries.

(iii) The aggregation of a number of these vacancies constitutes a "cavity", which rapidly increases in size. The initial cavities appear to be widely spaced.

(iv) New cavities are generated, so that ultimately they link up to form a crack.

(v) Probably the stress concentration at the edges of the crack aids its subsequent spread.

It is of interest to note that intercrystalline cracking of brass by mercury under stress produces clean separation of boundaries without the formation of these cavities.

Mr. D. R. Miller, working in these laboratories, has found that O.F.H.C. copper also shows the same phenomenon when strained between 300° and 500° C. A systematic investigation is in progress.

J. NEILL GREENWOOD
Research Professor of Metallurgy.

The Baillieu Laboratory,
University of Melbourne,
Australia.

REFERENCES

1. M. E. Whitaker, *Metallurgia*, 1948, **39**, 21.
2. J. Hérenguel and M. Scheidecker, *Rev. Mét.*, 1951, **48**, 173.

The Hardness of Primary Substitutional Nickel Alloys

The effect of a number of alloying elements on the Vickers and Meyer hardness of nickel was studied under conditions of controlled grain-size for atomic concentrations up to 5%. The nickel–tin alloys were supersaturated at room temperature, and the nickel–silicon alloys were nearly supersaturated. The equilibrium diagram of the system nickel–antimony does not seem to be well known in the range of small antimony contents.

The hardness of nickel was increased by all the alloying elements. Except for the alloys of the three systems mentioned above, the hardness increased linearly with the atomic concentration (Fig. 1). The gradient of the hardness/concentration curve for the nickel–silicon alloy increased, whereas in the alloys containing tin and antimony this gradient decreased, with increasing concentration of the alloying element. Similar curves were obtained at −183° and 300° C. Rather crude experiments indicated that although the hardness of the alloy, H_{alloy}, decreased with increasing temperature, the increase in hardness due to alloying (i.e. $H_{\text{alloy}} - H_{\text{nickel}}$) was approximately independent of the temperature in the range −183° to 300° C.

It was found that the index n occurring in Meyer's law,[1] which may be regarded as a measure of the ductility of the alloy,[2] decreased with increasing concentration of the alloying element, and this was particularly marked in the case of

alloys containing elements which harden nickel considerably. This suggests a decrease in ductility with increasing concentration of the solute.

The effect of cobalt,[3] iron,[4, 5, 6] silicon,[7] copper,[8, 9] chromium,[10, 11] aluminium,[12] manganese,[13, 14] and molybdenum[15] on the lattice parameter of nickel has been studied by various authors. Conflicting results on the effect of chromium and manganese on the lattice parameter are found in the literature. The effect of these elements, together with the effect of antimony and tungsten, on the lattice parameter of nickel was determined. For the small concentrations studied, the lattice parameter of these alloys varied linearly with the atomic concentration. Expressing these results as $\epsilon = (1/a)da/dc$, where a is the lattice parameter and c the fractional number of solute atoms present in the alloy, it was found that $\epsilon = 0{\cdot}040$, $0{\cdot}091$, $0{\cdot}18$, and $0{\cdot}30$ for chromium, manganese, tungsten, and antimony solutions in nickel, respectively. The quantity ϵ is a measure[16] of the lattice strains produced by the solute atoms. The Vickers hardness per at.-% was found to increase approximately linearly with the absolute value of ϵ (Fig. 2).

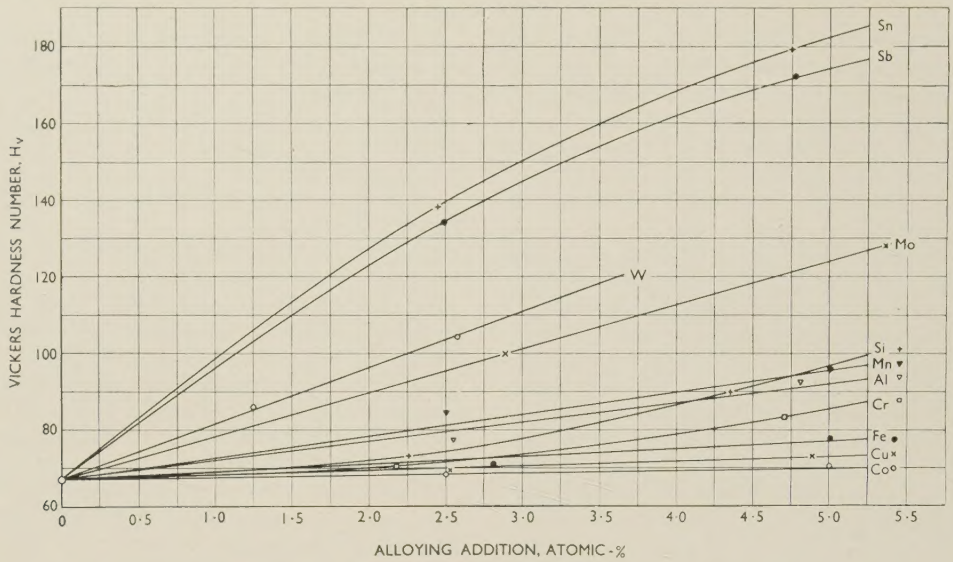


FIG. 1.—Vickers Hardness as a Function of the Atomic Concentration for Nickel Alloys.

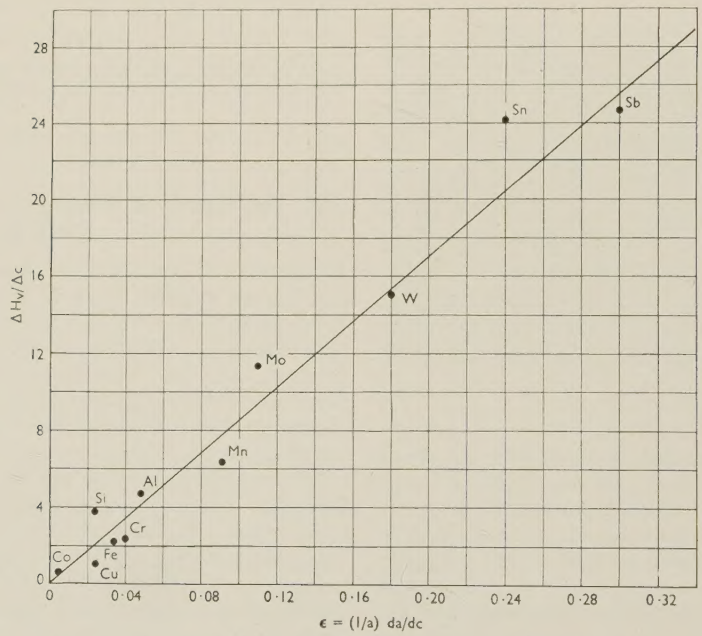


FIG. 2.—Increase in Vickers Hardness per At.-% as a Function of ϵ.

If $\sigma = ge^x$ represents the stress/strain curve of an annealed metal, where σ is the true stress and e the plastic strain, then the Vickers hardness, H_0, of the annealed metal can be written as:[1]

$$H_0 = 3{\cdot}0\ g\ (0{\cdot}08)^x \quad . \quad . \quad . \quad . \quad (1)$$

and that of the metal cold-worked by an amount e, as:

$$H_e = 3{\cdot}0\, g\, (e + 0{\cdot}08)^x \quad . \quad . \quad . \quad . \quad (2)$$

In the case of annealed cubic metals,[17,18] $x \sim \frac{1}{2}$, whereas in the case of dilute alloys, x decreases slightly with increasing concentration. This slight decrease will be neglected in what follows. As is easily seen from equations (1) and (2), the relation between the difference in hardness of the alloy and solute when both are cold-worked by an amount e, i.e. ΔH_e, and the difference in hardness between alloy and pure metal in the annealed condition, ΔH_0, is

$$\Delta H_e = (e + 0{\cdot}08/0{\cdot}08)^{1/2} \Delta H_0 \quad . \quad . \quad (3)$$

Equation (3) is independent of the nature of the alloy. By plotting ΔH_e for the different alloys, corresponding to reductions of 10 or 70%, against ΔH_0, it was found that all the points for the different nickel alloys fell on the same straight line passing through the origin. This result is in accordance with equation (3). The experimental values for the gradients of the straight lines obtained for reductions of 10 and 70% were 1·4 and 2·0, respectively, whereas the calculated values for the gradients (from equation (3)) are 1·5 and 3·1. Similar curves were published by Brick, Martin, and Angier[19] for copper alloys. The experimental values for the gradients of the lines in their figures for 20 and 60% reductions are 1·7 and 2·6, respectively, whereas the corresponding calculated values are 1·9 and 2·9.

Obviously, the results given in this discussion (not considering alloys containing tin, silicon, and antimony) are roughly in accordance with the assumption that the stress/strain curve of the nickel alloys is given by:

$$\sigma = (B|\epsilon|c + 1) f(e) \text{ or } H_v = 3{\cdot}0(B|\epsilon|c + 1) f(0{\cdot}08)$$

where H_v represents the Vickers hardness, B some constant of the basis metal, and $\sigma_0 = f(e)$ the stress/strain curve of pure nickel, which may be approximated by $\sigma = ge^{1/2}$.

The work described here was carried out under the direction of Professor M. J. Druyvesteyn (Delft). The author wishes to thank the South African Council for Scientific and Industrial Research for financial support which enabled him to carry out this work and for permission to publish these results.

M. A. Meyer

Council for Scientific and Industrial Research,
Pretoria,
South Africa.

REFERENCES

1. D. Tabor, *Proc. Roy. Soc.*, 1948, [A], **192**, 247.
2. D. Tabor, *J. Inst. Metals*, 1951, **79**, 1.
3. A. Osawa, *Sci. Rep. Tôhoku Imp. Univ.*, 1930, [i], **19**, 109.
4. A. J. Bradley, A. H. Jay, and A. Taylor, *Phil. Mag.*, 1937, [vii], **23**, 545.
5. E. R. Jette and F. Foote, *Trans. Amer. Inst. Min. Met. Eng.*, 1936, **120**, 259.
6. E. A. Owen and A. H. Sully, *Phil. Mag.*, 1941, [vii], **31**, 314.
7. A. Osawa and M. Okamoto, *Sci. Rep. Tôhoku Imp. Univ.*, 1939, [i], **27**, 326.
8. L. Vegard and H. Dale, *Z. Krist.*, 1928, **67**, 148.
9. E. A. Owen and L. Pickup, *ibid.*, 1934, **88**, 116.
10. E. R. Jette, V. H. Nordstrom, B. Queneau, and F. Foote, *Trans. Amer. Inst. Min. Met. Eng.*, 1934, **111**, 361.
11. W. C. Phebus and F. C. Blake, *Phys. Rev.*, 1925, [ii], **25**, 107.
12. A. J. Bradley and A. Taylor, *Proc. Roy. Soc.*, 1937, [A], **159**, 56.
13. S. Valentiner and G. Becker, *Z. Physik*, 1935, **93**, 795.
14. S. Kaya and A. Kussmann, *ibid.*, 1931, **72**, 293.
15. G. Grube and H. Schlecht, *Z. Elektrochem.*, 1938, **44**, 413.
16. F. R. N. Nabarro, *Proc. Phys. Soc.*, 1946, **58**, 669.
17. F. Seitz, "The Physics of Metals", p. 85. New York: 1943. (McGraw-Hill).
18. Ch. Crussard and B. Jaoul, *Rev. Mét.*, 1950, **47**, 489.
19. R. M. Brick, D. L. Martin, and R. P. Angier, *Trans. Amer. Soc. Metals*, 1943, **31**, 675.

Low-Stress Torsional Creep Properties of Pure Aluminium

The comments made by Dr. Richards and Dr. Yeomans (*Bulletin*, 1952, **1**, (12), 106) on the results of my low-stress torsional creep tests on super-purity aluminium raise interesting possibilities with regard to the effects of preferred orientation on the properties of the grain boundaries, but examination of the test-pieces used in the work indicates that neither suggestion is a likely explanation of the observed results.

The drawn rod before annealing showed the fibre structure to be predominantly ⟨111⟩ with a small proportion of ⟨100⟩, but after annealing at all temperatures between 300° and 600° C. no trace of ⟨111⟩ structure remained and the structure was entirely ⟨100⟩. So far as could be judged from the X-ray photographs, the perfection of the preferred orientation remained unchanged throughout the series, although the range of scatter could not be judged very accurately for the coarser-grained specimens, since the lines remained spotty in spite of scanning a considerable area of the surface of the rod. Thus there would appear to be no difference in the character of the preferred orientation to explain the progressive change in creep strain with increasing annealing temperature. In any case, large differences in orientation between adjacent grains would still be present even in a perfect drawing texture, since orientation around the fibre axis is random, and some doubt is felt as to whether the average viscosity of grain boundaries with a common direction in the adjacent lattices would be significantly less than that of boundaries between grains of quite random orientation.

The possibility of easy rotation of glide planes similar to that quoted by Jillson for zinc single crystals does not appear to exist in the present case, since the recrystallized structures all had a ⟨100⟩ fibre axis.

Dr. Kennedy (*ibid.*) has analysed the experimental curves of creep strain in terms of a power function of time and in terms of the modified Andrade equation, and has shown that in either case a close fit can be obtained, with the constants related in a simple manner to the grain-size. I had already made such an analysis, but in the interests of brevity, and since the results do not immediately lead to a satisfactory explanation of the mechanism operating, they were not included in my original note.

Some error appears to have been made in Kennedy's Fig. 3, for the β and κ values plotted do not give curves in agreement with the original experimental curves; the nature of the error is not readily apparent.

Further work in this field has led to the conclusion that the creep strain observed may not be associated with grain-boundary viscous flow, and it is hoped to report the findings more fully at a later date.

W. Betteridge

The Mond Nickel Co., Ltd.,
Development and Research Dept. Laboratory,
Birmingham 16.

DIARY

A copy of the Programme of Meetings of Local Sections and Associated Societies for the Session 1952–53 has now been sent to all members resident in the British Isles. Overseas members may obtain a copy on application to the Secretary.

Local Sections

2 October. London. Chairman's Address: "Some Useful Techniques in Metallurgical Research", by Dr. C. E. Ransley. (4 Grosvenor Gardens, London, S.W.1, at 7.0 p.m.)

7 October. Oxford. "The Importance of Fuel and Power in Metallurgy", by C. G. Conway. (Black Hall, St. Giles, Oxford, at 7.0 p.m.)

7 October. South Wales. "Extrusion", by Christopher Smith. (Metallurgy Department, University College Singleton Park, Swansea, at 6.30 p.m.)

13 October. Scottish. Visit to Massey-Harris, Ltd., Kilmarnock.

20 October. Sheffield. "Some Reminiscences of a Recent Visit to the U.S.A.", by Dr. E. Gregory. Joint meeting with the Sheffield Society of Engineers and Metallurgists and the Sheffield Metallurgical Association. (The University, St. George's Square, Sheffield 1, at 7.30 p.m.)

31 October. Birmingham. Open Discussion on "Aluminium *v.* Steel as Structural Material". (James Watt Memorial Institute, Gt. Charles Street, Birmingham 3, at 6.30 p.m.)

Other Societies

2 October. Leeds Metallurgical Society. Presidential Address. (Chemistry Department, The University, Leeds 2, at 7.0 p.m.)

7–9 October. Iron and Steel Institute. Special Meeting in Swansea.

15 October. Manchester Metallurgical Society. Presidential Address by H. Allison. (Engineers' Club, Albert Square, Manchester, at 6.30 p.m.)

15 October. North East Metallurgical Society. Lecture by Dr. J. W. Jenkin. (Cleveland Scientific and Technical Institution, Middlesbrough, at 7.15 p.m.)

16 October. Liverpool Metallurgical Society. Presidential Address by R. S. Brown. (Lecture Theatre, Electricity Service Centre, Whitechapel, Liverpool, at 7.0 p.m.)

20–25 October. Société Française de Métallurgie. Journées d'Automne. (Maison de la Chimie, 28 rue St. Dominique, Paris 7e.)

22 October. Institute of Metal Finishing. First Hothersall Memorial Lecture: "A. W. Hothersall—An Appreciation of his Contribution to Electrodeposition", by Dr. G. E. Gardam. (Windsor Room, Grand Hotel, Birmingham, at 2.30 p.m.)

23 October. Institution of Production Engineers, Wolverhampton Graduate Section. "Electroplating and Metal-Finishing Processes", by A. F. Brockington. (County Technical College, Wednesbury, at 7.30 p.m.)

28 October. Iron and Steel Institute. Discussion on "The Corrosion of Steel Under Phosphate Coatings and Protective Finishes". (4 Grosvenor Gardens, London, S.W.1, at 2.0 p.m.)

29 October. Manchester Metallurgical Society. "Cold Working of Metals", by Dr. T. Ll. Richards. (Engineers' Club, Albert Square, Manchester, at 6.30 p.m.)

APPOINTMENTS VACANT

A CHEMIST is required by a fundamental research laboratory to work on problems in physical metallurgy. A good honours degree and considerable research experience are required. Apply in writing to Personnel Officer, Research Laboratory, Associated Electrical Industries, Ltd., Aldermaston Court, Aldermaston, Berkshire.

GRADUATE in physics or metallurgy, preferably with knowledge of powder metallurgy and with mechanical or engineering aptitude, for research and development. Watford area. Write particulars of qualifications and career. Box No. 339, Institute of Metals, 4 Grosvenor Gardens, London, S.W.1.

LECTURERS AND SENIOR LECTURERS IN PRIMARY AND NON-FERROUS METALLURGY, NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

Applications are invited for appointment to lecturing positions in the New South Wales University of Technology. Opportunities exist for appointment to, or advancement to, the position of Senior Lecturer. Salary: Lecturer—£1082 (Australian) per annum range £1382 (Aust.) per annum; Senior Lecturer—£1282 (Aust.) per annum range £1532 (Aust.) per annum. Commencing salary in accordance with qualifications and experience. Successful applicants will be eligible, subject to medical examination, to contribute to the State Superannuation Fund. Appointment in first instance to Newcastle University College, but appointees must be prepared to accept appointment to any centre in New South Wales. Applicants should possess appropriate Degree or Diploma, Honours standard being essential for Senior Lectureship. They should have had appropriate industrial or professional experience and be prepared to undertake research in special fields. The first-class shipping fare of the appointees to New South Wales will be paid. Six copies of applications (together with six copies of testimonials and any supporting documents) should reach the Agent General for New South Wales, 56 Strand, London, W.C.2, by 27 OCTOBER 1952. No special forms of application are available.

MULLARD BLACKBURN WORKS, LTD., require a Metallurgist for Laboratory investigations into the properties of, and the manufacturing processes for, tungsten and molybdenum wires. Applicants should possess a degree in metallurgy or the Associateship of the Institution of Metallurgists; experience in powder metallurgy or previous work on the recrystallization of metals would be an advantage, but a new graduate would be considered for the post. Salary in accordance with age and qualifications. Apply in writing, giving full details, to the Works Personnel Officer, Mullard Blackburn Works, Ltd., Philips Road, Blackburn, Lancs.

NELSON RESEARCH LABORATORIES, English Electric Co., Ltd., Stafford, have vacancies for two senior research scientists to study the influence of physical and metallurgical properties on the magnetic characteristics of ferromagnetic materials and the development of improved materials. Applicants must have a good honours degree and several years post-graduate and industrial experience on the physics and metallurgy of magnetic materials. Previous experience of leading a group is desirable but not essential. Please write giving full details and quoting reference 310C. to Central Personnel Services, English Electric Co., Ltd., 24–30, Gillingham Street, London, S.W.1.

UNIVERSITY OF BIRMINGHAM

Department of Industrial Metallurgy.

Research Fellowship

Applications are invited for appointment to a University Research Fellowship in Industrial Metallurgy. Candidates should be graduates in metallurgy, chemistry, or physics with research experience. The work of the Fellow will be either in the study of the properties of molten metals or in metallurgical thermodynamics. The initial salary will be £450 per annum, and the Fellowship carries with it the benefits of F.S.S.U. and child allowances.

Applications should be sent to reach the Registrar, The University, Edgbaston, Birmingham 15, not later than 31 October 1952.

The University,
Birmingham 3.

C. G. BURTON,
Secretary.